ATTACHMENT 9 – ECONOMIC ANALYSIS – FLOOD DAMAGE REDUCTION COSTS AND BENEFITS

APPENDIX C

City of Farmersville – Visalia Road Culvert Flow Analysis

VISALIA ROAD CULVERT FLOW ANALYSIS

City of Farmersville

May 2007

Quad Knopf

Visalia Road Culvert Flow Analysis

Prepared For:

City of Farmersville

Rene Miller, City Manager
909 W. Visalia Rd.
Farmersville, CA 93223
(559) 747-3306

Approved By:
City of Farmersville
5110 West Cypress Avenue
Visalia, CA 93277
(559) 733-0440

David Jacobs, City Contract Engineer

Prepared By:

Quad Knopf
5110 West Cypress Avenue
Visalia, CA 93277
(559) 733-0440

Ralph Hogoboom, Civil Engineer

Reviewed By:

Consolidated Peoples Ditch Company
15370 Avenue 256
Visalia, CA 93292

Dennis Keller, Consulting Engineer
209 South Locust Street
Visalia, CA 93291
(559) 733-0440

May 2007

F00006

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CHAPTER 1
SUMMARY AND RECOMMENDATIONS

Chapter 1 - Summary and Recommendation

Summary

The project involving the widening of Visalia Road through the City of Farmersville will require many improvements, including the enlargement of the Deep Creek culvert. The purpose of this study is to determine the design flow for the proposed new culvert. The existing Deep Creek culvert was originally built in 1930 and enlarged in 1950.

Deep Creek is a man made irrigation/flood release channel and its irrigation flows are regulated by the Terminus Dam at Lake Kaweah. The channel flows through Farmersville from the Northeast to the Southwest (Figure 2-1). As the channel enters the city limits of Farmersville, the flow is impacted by existing structure capacities and the runoff from adjacent areas of the City.

Deep Creek is operated by the Consolidated Peoples Ditch Company. The City and the Ditch Company have an existing agreement to allow storm water to discharge directly into the channel. The current adopted Storm Drain Master Plan shows existing and future development continuing to discharge into the creek.

Enlarging the existing culvert will provide the opportunity to modernize an aging structure that was designed and constructed with standards that have since been revised and updated. It has been determined that replacement of the culvert during the Visalia Road widening project is more practical than adding on to an existing culvert that is close to its life expectancy. The design of the new structure is based upon the 100-year flow recommended below.

Recommendation

The flow used for design of the proposed Deep Creek culvert at Visalia Road in the City of Farmersville should provide equal or increased flood protection than the existing culvert currently provides. A 1983 FEMA Insurance Flood Study (FIS) uses a flow rate of 1300 cubic feet per second (cfs) through the existing Visalia Road culvert.

Storm water runoff from the adjacent areas of existing and future development within the City Limits is calculated to be 853 cfs through the Visalia Road culvert structure. This is a conservative estimate due to the use of the rational methodology, and the variance of the time of concentrations and lag time for each subbasin. Also, during a 100-year storm, the peak flow of flood water released from Lake Kaweah is hours behind the storm water from the adjacent developed areas. The conservative methodology used in this study was chosen, because a detailed hydrologic analysis of Deep Creek was not feasible for the purpose of this culvert design analysis.

Following completion of the flow analysis, four options were identified and are outlined below along with a brief comparison of available flow areas for existing structures.

Option 1—Use the FEMA flow at the Rail Road Bridge, 1550 cfs
Option 2—Use the FEMA flow at the Visalia Culvert, 1300 cfs
Option 3—Use the FEMA flow + City Runoff, 1300 + 853 = 2153 cfs
Comparison 1—Calculation of existing structure available flow areas

Option 1: Use the FEMA flow at the Rail Road Bridge, 1550 cfs

This option is very conservative, as the flow rate at the existing Visalia Road culvert is identified as being 1300 cfs in the 1983 FIS. A flow rate of 1550 cfs can not be accommodated in the existing upstream channel and associated structures and would therefore not reach the new culvert structure without modification of this upstream infrastructure.

Option 2: Use the FEMA flow at the Visalia Culvert, 1300 cfs

Based on the existing channel analysis described in Chapter 2, this would be a reasonable culvert design flow.

Option 3: Use the FEMA flows + City Runoff, 1300 + 853 = 2153 cfs

Option 3 is very conservative and has drawbacks similar to those presented in Option 1. Utilization of the 2153 cfs flow rate for the design of the new Visalia Road culvert is unnecessary unless the upstream channel and associated structure are modified to accommodate this flow rate.

Comparison 1: Calculation of existing structure available flow areas

A field inspection of the existing flood control structures in Deep Creek between Marinette Road and Visalia Road demonstrated that flow through the structures is currently affected by the amount of sediment present in the structures. The area of the existing structure opening was field measured and calculated. The open area was then estimated for each structure based on a proposed condition following sediment removal. These areas are shown in Figure 2.2. No structure capacities were calculated due to insufficient hydraulic data.

Conclusion

Based on this analysis, Option 2, with a flow rate of 1300 cfs, provides a reasonably conservative flow rate on which to base the design of the new Visalia Road culvert. Since the FEMA regulated flow rate is higher than what can currently be accommodated in the upstream channel and associated structures, it is therefore conservative for the design of this structure. The 100-year, 24-hour peak runoff associated with recent and future development in the City of Farmersville of 853 cfs is much lower than our recommended design flow of 1300 cfs, and should be easily passed by the new culvert prior to the passage of peak flows associated with releases of flood water from the Terminus Dam.

CHAPTER 2
FLOW ANALYSIS

Chapter 2 - Flow Analysis

This flow analysis required research of previous studies of the Deep Creek hydraulics and hydrology, and identification of the existing infrastructure of the creek itself. The Visalia Road culvert was built in the 1930's and was enlarged in the 1950's. Since the 1950's, land uses have changed extensively in the area surrounding the creek, resulting in different 100-year peak flow rates and infrastructure changes. These changes have been incorporated into this study to determine an appropriate flow rate to use for design of the proposed Visalia Road culvert. Since this structure is in a well developed area within the City of Farmersville (Figure 2-1), this analysis was conducted to ensure the proposed culvert design provides flood protection equal to or greater than the level of protection provided by the existing structure.

Six cross sections of the existing ditch were field surveyed and are illustrated in Figure 2-7 through 2-8. The existing channel capacity was calculated at six of the surveyed sections upstream of the proposed culvert. Channel geometrics were calculated from the survey data. The lower of the two top of bank elevations for each section was used to calculate the area and wetted perimeter. Cross sections plotted from the point data are shown in Figures 2-7 through 2-8. A channel capacity for the cross section surveyed immediately upstream of the existing Visalia Road culvert was not used to calculate the existing channel capacity because the channel contracted in order to transition into the existing culvert, resulting in a reduction of flow at this location. A channel capacity for the cross section surveyed immediately upstream from the Marinette Road crossing was also not calculated as there was insufficient data available to calculate a slope upstream of the crossing.

Channel slope was calculated using the lowest point in each of two cross sections for the reach being evaluated and the distance between the two sections. If the two sections abutted a culvert or bridge then the slope was calculated using the cross section immediately downstream of the structure and the cross section just upstream of section abutting the upstream end of the structure. The slope calculated for section 5 was also used for Section 6 since there is insufficient data to calculate an upstream slope.

A composite n-value of 0.025 was used in Manning's formula. The existing channel was assumed to have n-values of 0.030 and 0.020 for the sides and bottom, respectively.

The calculations for channel capacity are contained in Figures 2-7 through 2-8. The calculated flow rate for each section is shown in Table 2-2.

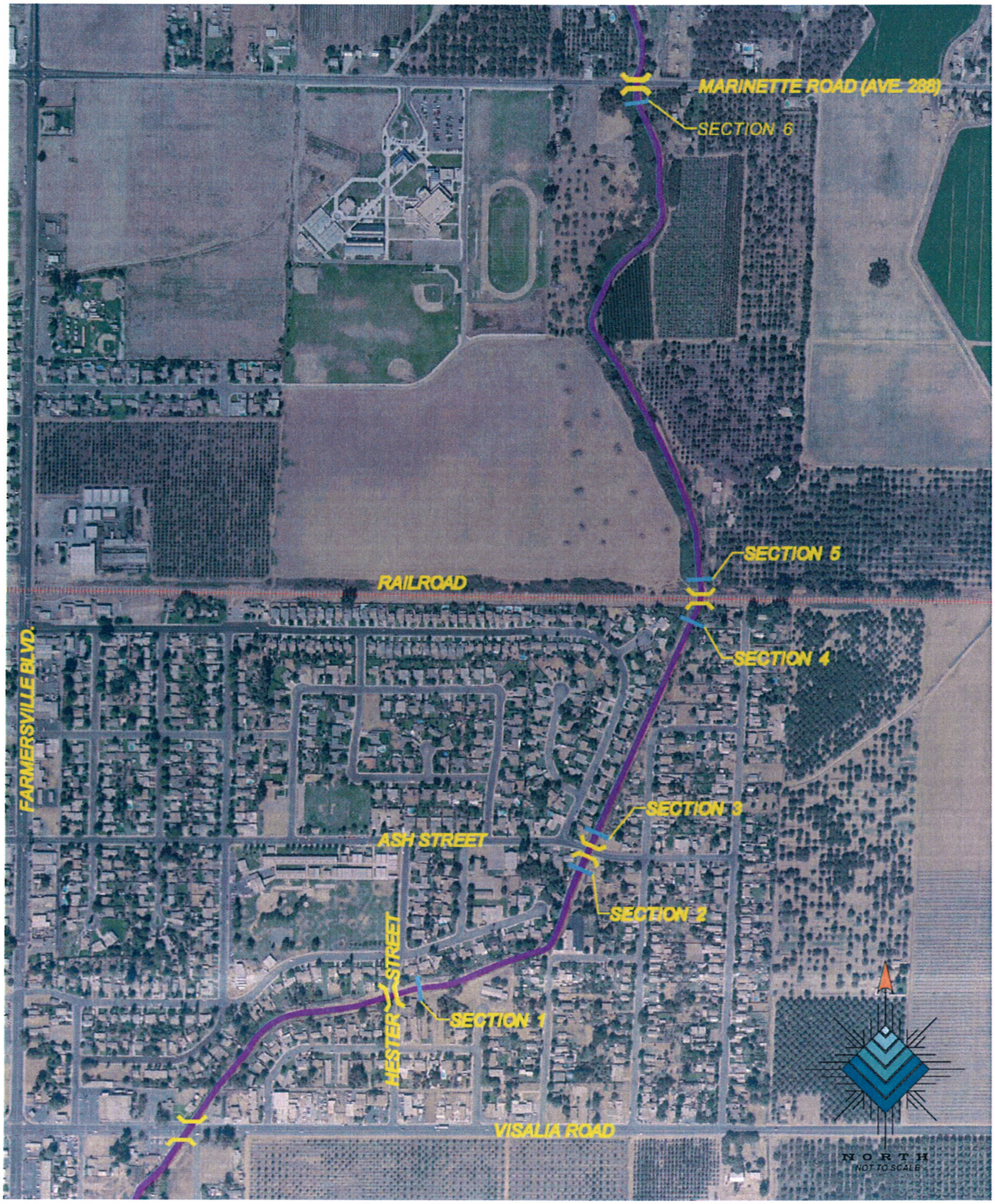
A design flow rate of 1300 cfs appears to be a reasonable number for the capacity of the channel upstream and is consistent with the FEMA regulated flow rate at the proposed culvert. Although the channel capacity diminishes just upstream from the proposed culvert, it is recommended that 1300 cfs be used for design of the culvert, with the assumption that the channel just upstream of the culvert may be modified in the future to accommodate the recommended design flow.

The City of Farmersville Storm Drain Master Plan (1989) was used to determine the amount of runoff from the property adjacent to Deep Creek. Runoff values from both existing and future development (Table 2-1) within the City Limits were accumulated at various connection points to the Deep Creek conveyance system between Marinette and Visalia Roads. Area II (Figure 2-10) was not included in this analysis, because it discharges into the Extension Ditch. Table 2-2 includes cross-sectional areas, velocities, and flow calculations for the Deep Creek system between Marinette Road and Visalia Road.

The FEMA Flood Insurance Study (FIS), dated June 15, 1983, was examined to determine how the flow through this channel was calculated and for comparison with the flow rates calculated in this study. A copy of this study is included in the appendix of this report. Since the 1983 FIS the Terminus Dam has been renovated, increasing Lake Kaweah's capacity. Lake Kaweah is the main source of water that is delivered through the Deep Creek conveyance system. The increase in capacity to the lake has added flood protection to Farmersville and other local communities in the basin.

The FIS states the hydrologic analysis approach that was used for the study to establish a peak discharge-frequency flow. The Deep Creek study was part of an overall hydrologic analysis of the Kaweah River distribution system conducted by FEMA. The FEMA report shows the peak 100-year flow rate from Marinette Road to the Rail Road Structure as 2859 *cfs*, the Rail Road Structure to Farmersville Boulevard at 1550-1300 *cfs*(Table 2-2).

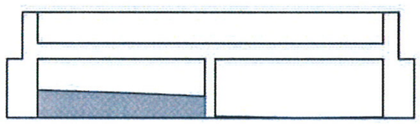
Ultimately, the existing channel geometry and associated structures dictate the design of the proposed culvert. When the ditch is flowing full, without any free board, the system is at its maximum capacity and any excess water will over-top the channel banks and follow existing drainage patterns in the City. The flowing full capacity of the upstream channel therefore provides the best design flow for the new Visalia Road culvert.



Quad Knopf

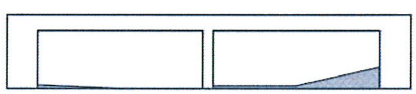
UPSTREAM DEEP CREEK CONVEYANCE SYSTEM
VISALIA ROAD CULVERT FLOW ANALYSIS

Figure 2 - 1



CURRENT AREA = 143.00 SF.
DESIGN AREA = 182.85 SF.

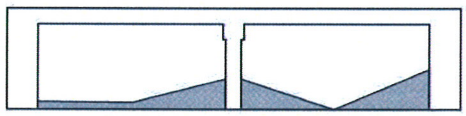
VISALIA ROAD
LOOKING NORTH



CURRENT AREA = 165.42 SF.
DESIGN AREA = 178.00 SF.

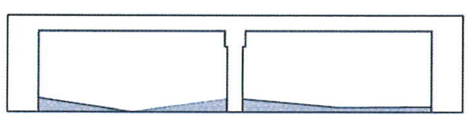
VISALIA ROAD
LOOKING SOUTH

Quad Knopf	VISALIA ROAD CULVERT VISALIA ROAD CULVERT FLOW ANALYSIS	Figure 2-2



CURRENT AREA = 242.48 SF.
DESIGN AREA = 295.62 SF.

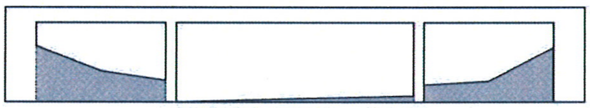
HESTER STREET
LOOKING WEST



CURRENT AREA = 257.16 SF.
DESIGN AREA = 280.73 SF.

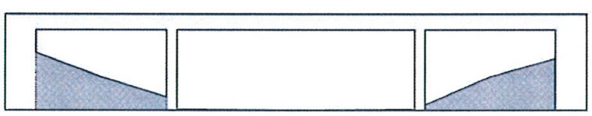
HESTER STREET
LOOKING EAST

Quad Knopf	HESTER STREET CULVERT VISALIA ROAD CULVERT FLOW ANALYSIS	Figure 2-3



CURRENT AREA = 283.78 SF.
DESIGN AREA = 367.60 SF.

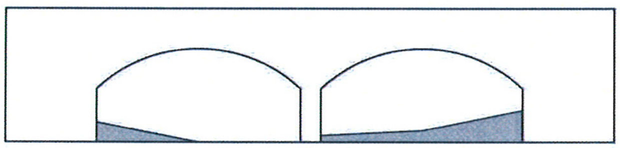
ASH STREET
LOOKING NORTH



CURRENT AREA = 288.69 SF.
DESIGN AREA = 367.60 SF.

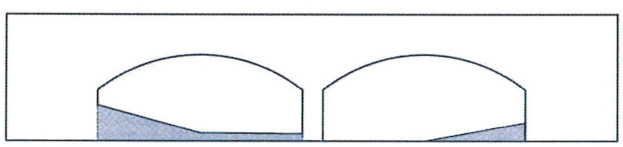
ASH STREET
LOOKING SOUTH

Quad Knopf	ASH STREET VISALIA ROAD CULVERT FLOW ANALYSIS	Figure 2-4



CURRENT AREA = 282.30 SF.
DESIGN AREA = 323.20 SF.

R.R. TRUSS
LOOKING NORTH



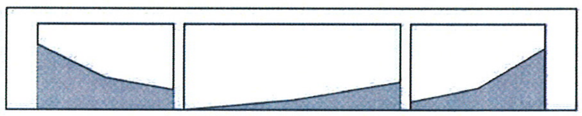
CURRENT AREA = 259.68 SF.
DESIGN AREA = 298.78 SF.

R.R. TRUSS
LOOKING SOUTH

Quad Knopf

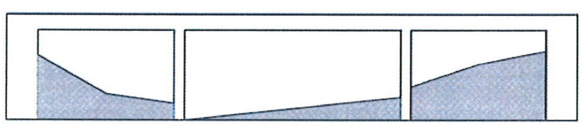
RAIL ROAD TRUSS CULVERT
VISALIA ROAD CULVERT FLOW ANALYSIS

Figure 2-5



CURRENT AREA = 281.82 SF.
DESIGN AREA = 387.75 SF.

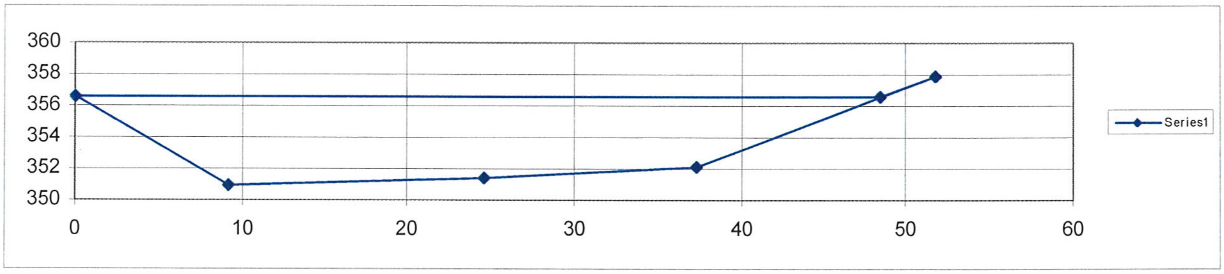
MARINETTE ROAD
LOOKING NORTH



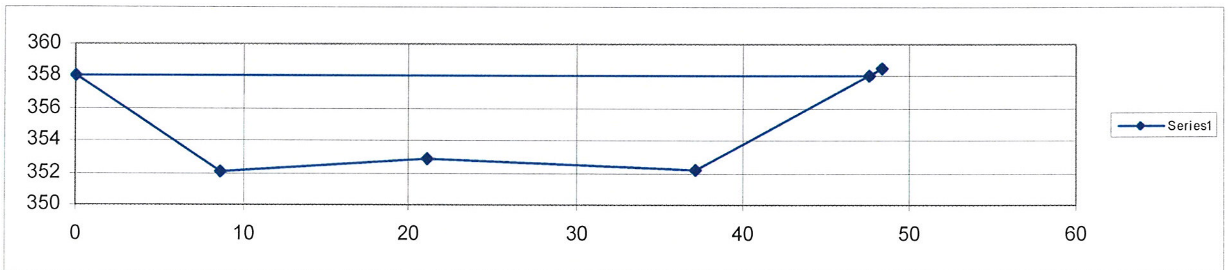
CURRENT AREA = 272.23 SF.
DESIGN AREA = 403.26 SF.

MARINETTE ROAD
LOOKING SOUTH

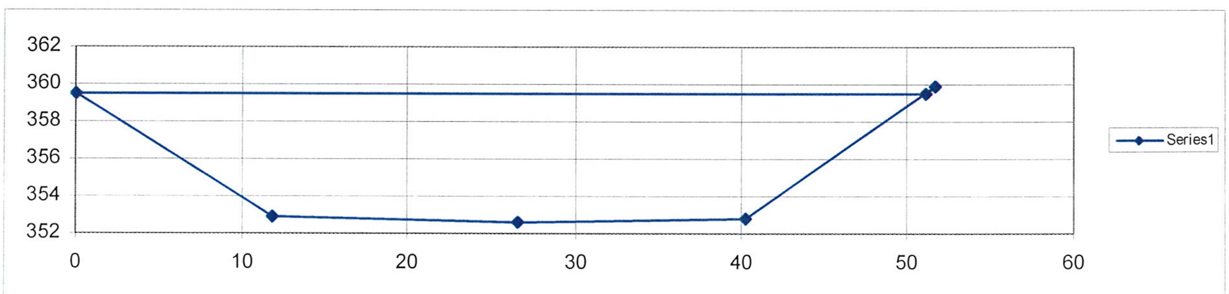
Quad Knopf	MARINETTE ROAD CULVERT VISALIA ROAD CULVERT FLOW ANALYSIS	Figure 2-6



SECTION 1
Current Area (ft.^{2}) = 196
Velocity (ft./sec) = 4.60
Flow (ft.^{3}/sec) = 902

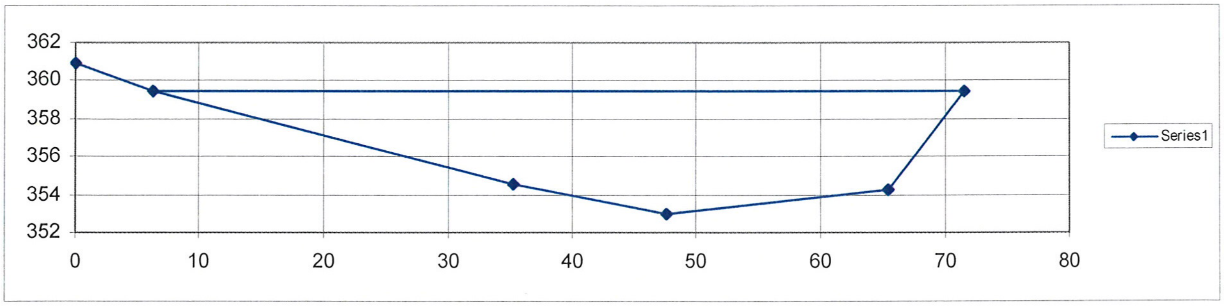


SECTION 2
Current Area (ft.^{2}) = 217
Velocity (ft./sec) = 7.31
Flow (ft.^{3}/sec) = 1586

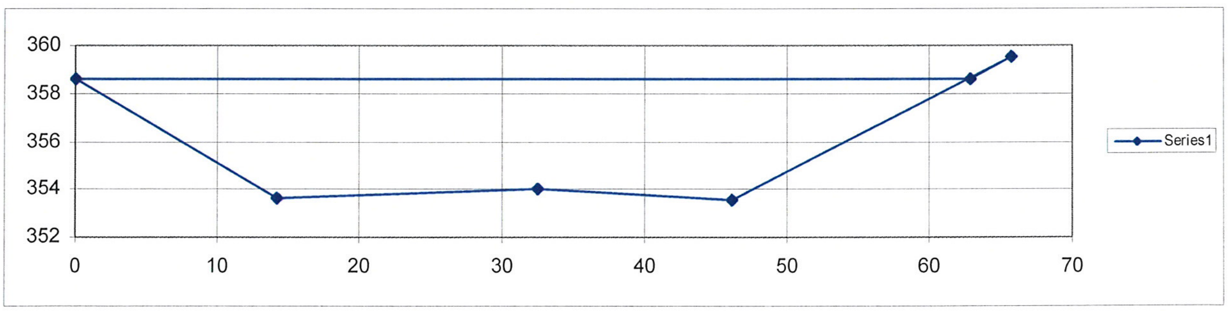


SECTION 3
Current Area (ft.^{2}) = 269
Velocity (ft./sec) = 6.12
Flow (ft.^{3}/sec) = 1645

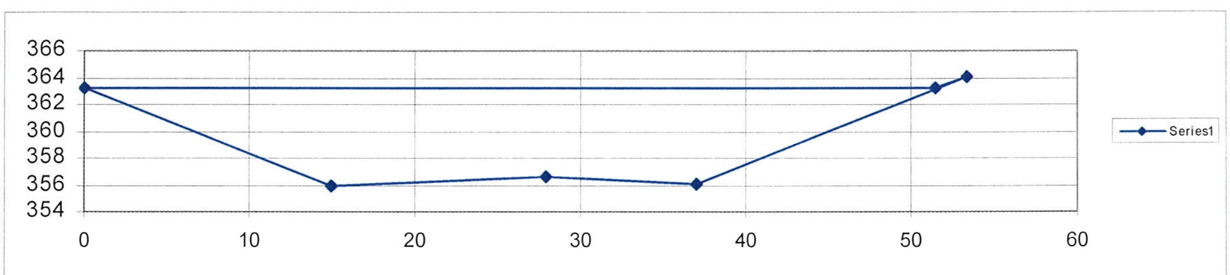
Quad Knopf	Cross Sections 1, 2, & 3 Visalia Road Culvert Flow Analysis	Figure 2-7



SECTION 4
Current Area (ft.^{2}) = 263
Velocity (ft./sec) = 4.62
Flow (ft.^{3}/sec) = 1216



SECTION 5
Current Area (ft.^{2}) = 232
Velocity (ft./sec) = 4.04
Flow (ft.^{3}/sec) = 937



SECTION 6
Current Area (ft.^{2}) = 259
Velocity (ft./sec) = 4.84
Flow (ft.^{3}/sec) = 1254

Quad Knopf	Cross Sections 4, 5, & 6 Visalia Road Culvert Flow Analysis	Figure 2-8

Table 2-1 Storm Drainage Analysis

Per the City of Farmersville Storm Drainage Master Plan adopted June 14, 1989, the following information was found. This data is to determine the 100-year peak discharge through the conveyance system for the proposed design of the Visalia Road Culvert.

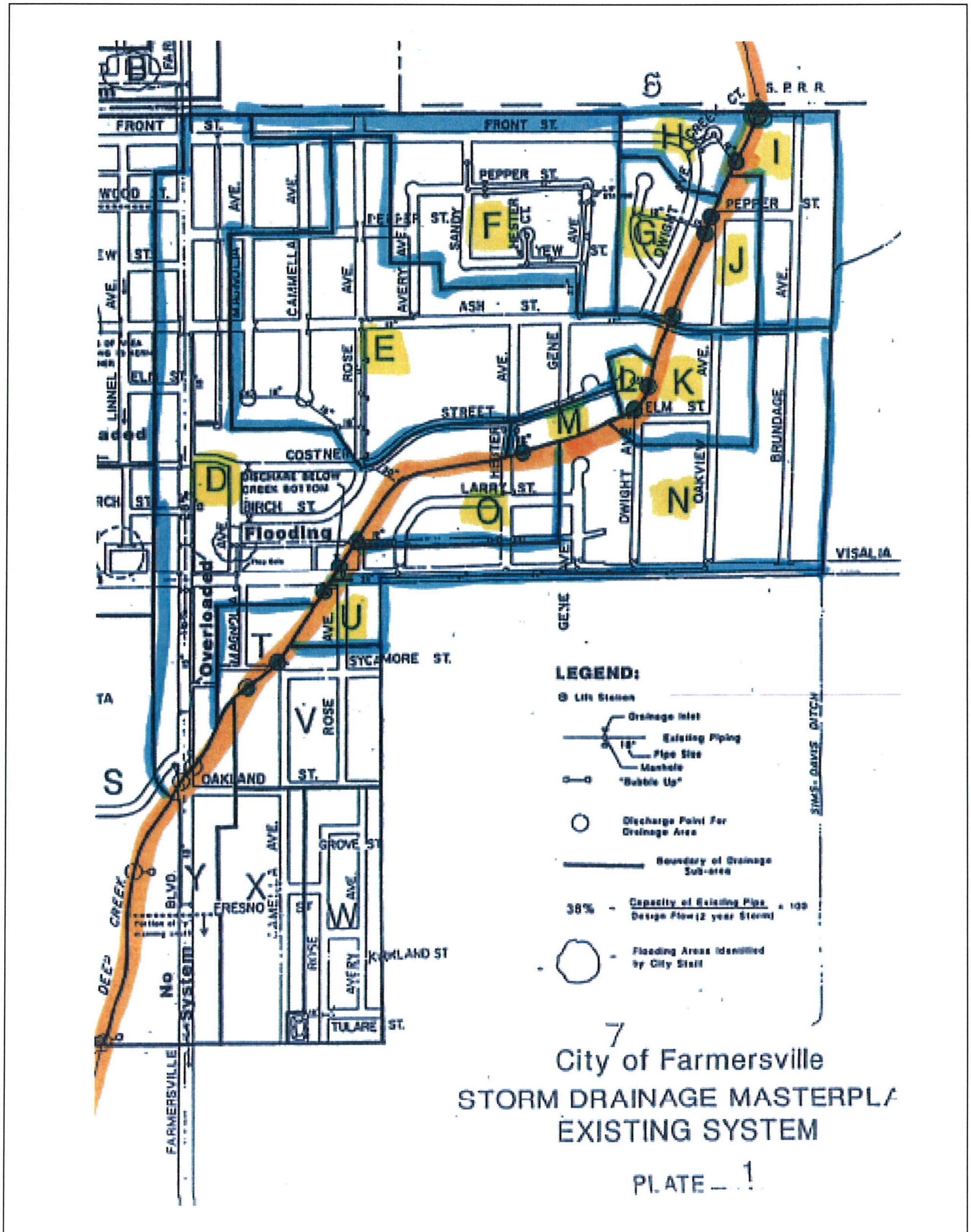
	Area		LAND USE		Weighted		Flow
Sub-Basin Area	(acres)	Commercial %	Residential %	Industrial %	C	I (in.)	*(cfs)*
D	65	80	20	0	0.72	3.70	173
E	71	0	100	0	0.40	3.70	105
F	30	0	100	0	0.40	3.70	44
G	14	0	100	0	0.40	3.70	21
H	8	0	100	0	0.40	3.70	12
I	17	0	100	0	0.40	3.70	25
J	9	0	100	0	0.40	3.70	13
K	15	0	100	0	0.40	3.70	22
L	3	0	100	0	0.40	3.70	4
M	4	0	100	0	0.40	3.70	6
N	47	25	75	0	0.50	3.70	87
O	14	0	100	0	0.40	3.70	21
AREA V	207	0	96	4	0.42	3.70	319
				Total Flow into Deep Creek			853 *cfs*

C Factors	
Commercial	0.80
Residential	0.40
Industrial	0.80

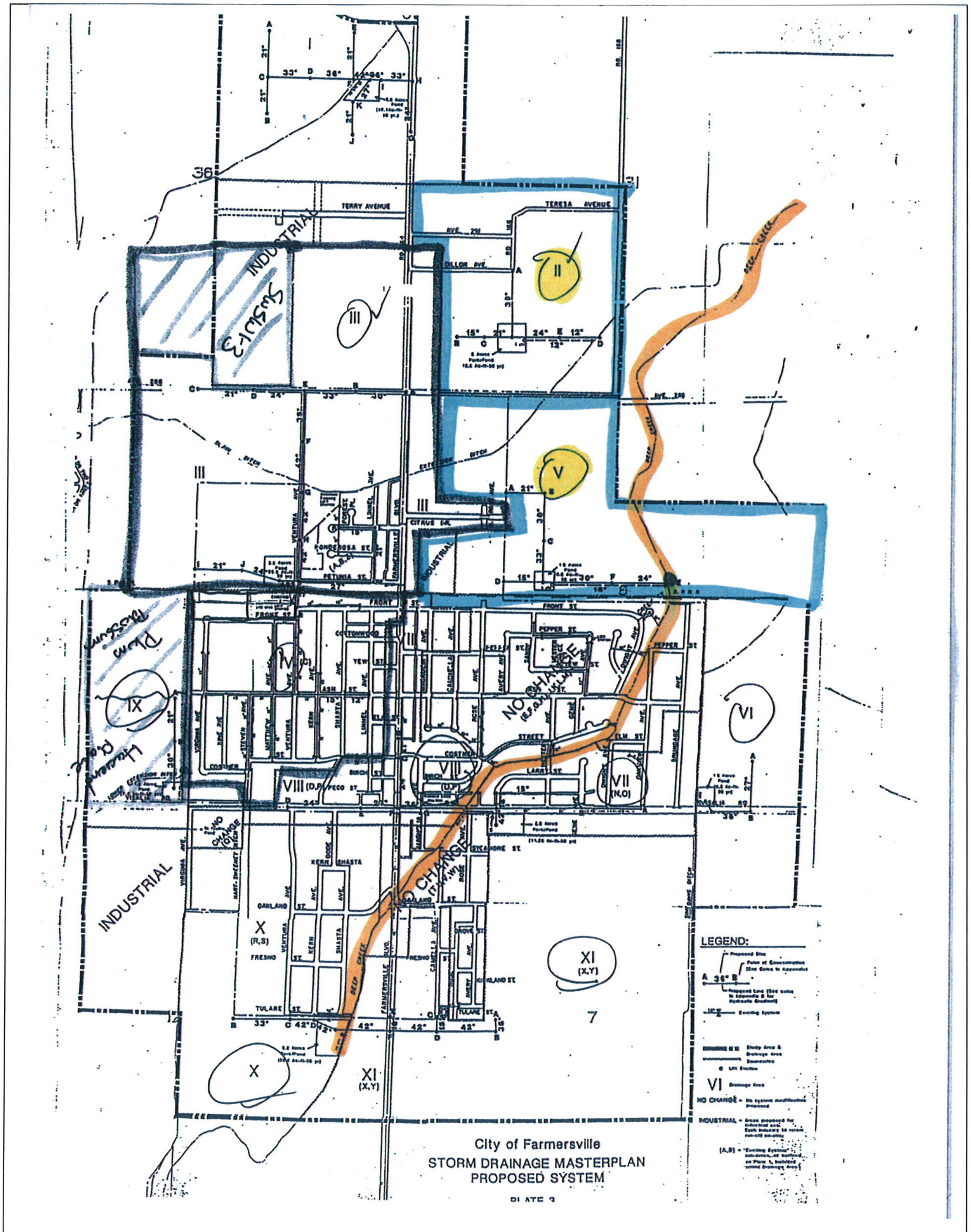
*NOTE:

1 3.70 in. is from the NOAA website for historical rainfall data in Visalia. This can be found in the Appendix.

2 Figure 2-9 and 2-10 detail areas within City of Farmersville



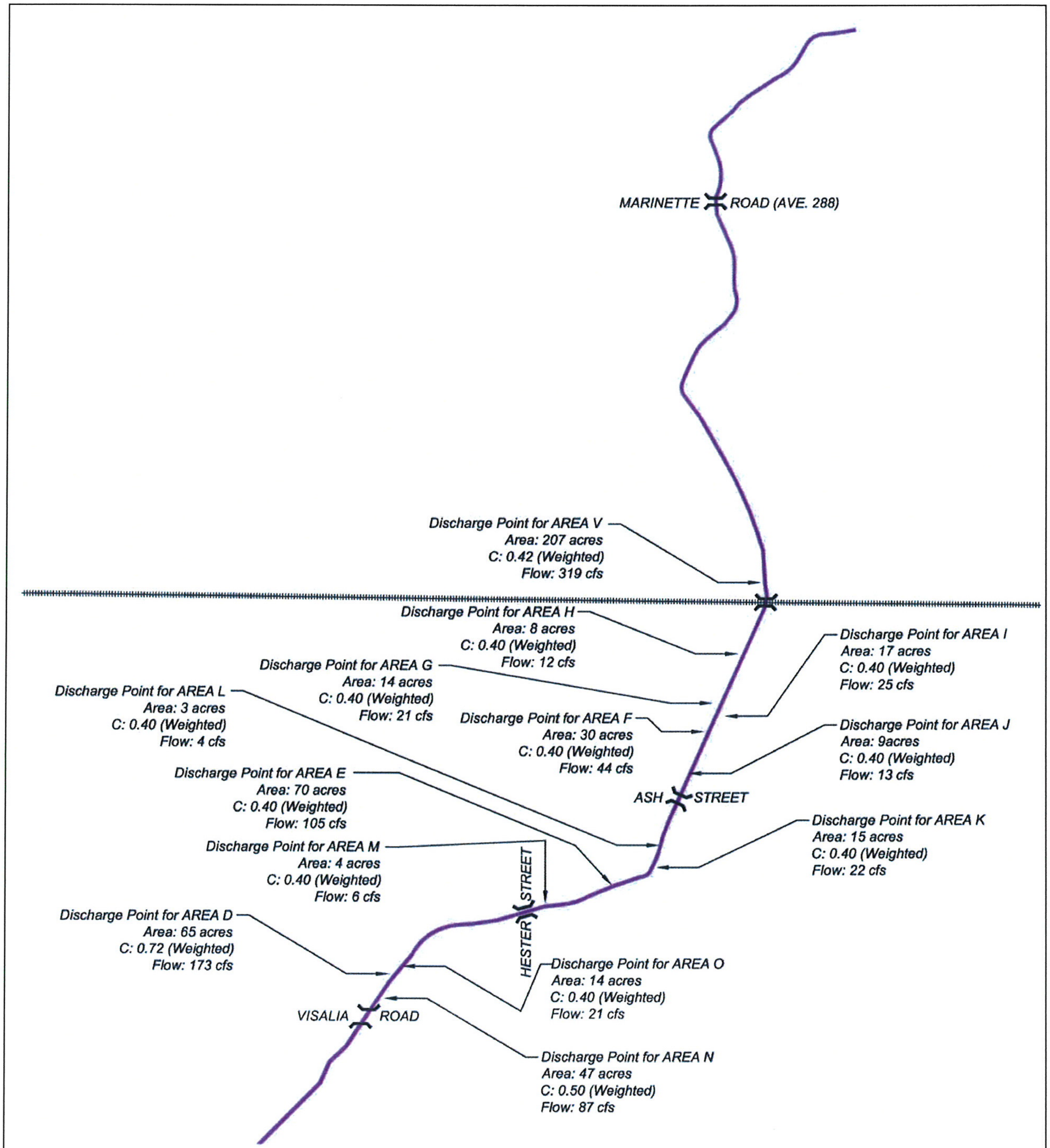
Quad Knopf	Farmersville Sub-basin Areas 1 Visalia Road Culvert Flow Analysis	Figure 2-9



Quad Knopf

Farmersville Sub-basin Areas 2
Visalia Road Culvert Flow Analysis

Figure 2-10



Quad Knopf

Farmersville Sub-basin Areas 2
Visalia Road Culvert Flow Analysis

Figure 2-11

Table 2-2 Structure Cross Sectional Area Table

Per topographical study and field visit the following areas were determined. Values for design and current areas are shown below.

Structure	Design Area (ft.^{2})	Current Area (ft.^{2})	Slope	Velocity (ft/sec)	Flow (ft^3/sec)	FIS Flow (ft^3/sec)
Visalia Road Inlet (Looking South)	178	165				1300
Visalia Road Outlet (Looking North)	183	143				1300
Open Channel between Structures	Not anaylzed because of restricted area					1300
Hester Street Inlet (Looking West)	296	242				1550
Hester Street Outlet (Looking East)	281	257				1550
Open Channel between Structures	Section 1	196	0.100%	4.60	902	1550
	Section 2	217	0.221%	7.31	1586	1550
Ash Street Inlet (Looking South)	368	289				1550
Ash Street Outlet (Looking North)	368	284				1550
Open Channel between Structures	Section 3	269	0.127%	6.12	1645	1550
	Section 4	263	0.099%	4.62	1216	1550
R.R. Truss Inlet (Looking South)	299	260				
R.R. Truss Outlet (Looking North)	323	282				
Open Channel between Structures	Section 5	232	0.083%	4.04	937	2859
	Section 6	259	0.083%	4.84	1254	2859
Marinette Road Inlet (Looking South)	403	272				2859
Mrinette Road Outlet (Looking North)	388	282				2859

APPENDIX A
NOAA DATA

NOWData - NOAA Online Weather Data

LINDSAY (044957)
Extremes
Highest Daily Precipitation (inches)
Days: 1/1 - 12/31
Length of period: 1 day
Years: 1913-2007

Rank	Value	Ending Date
1	3.57	12/6/1966
2	2.70	1/11/1940
3	2.47	1/19/1969
4	2.22	2/10/1978
5	2.02	1/2/2006
6	1.80	1/25/1999, 1/2/1922
8	1.74	3/3/1938
9	1.72	11/19/1967, 5/21/1921

Official data and data for additional locations and years are available from the Regional Climate Centers **and the** National Climatic Data Center.

NOWData - NOAA Online Weather Data

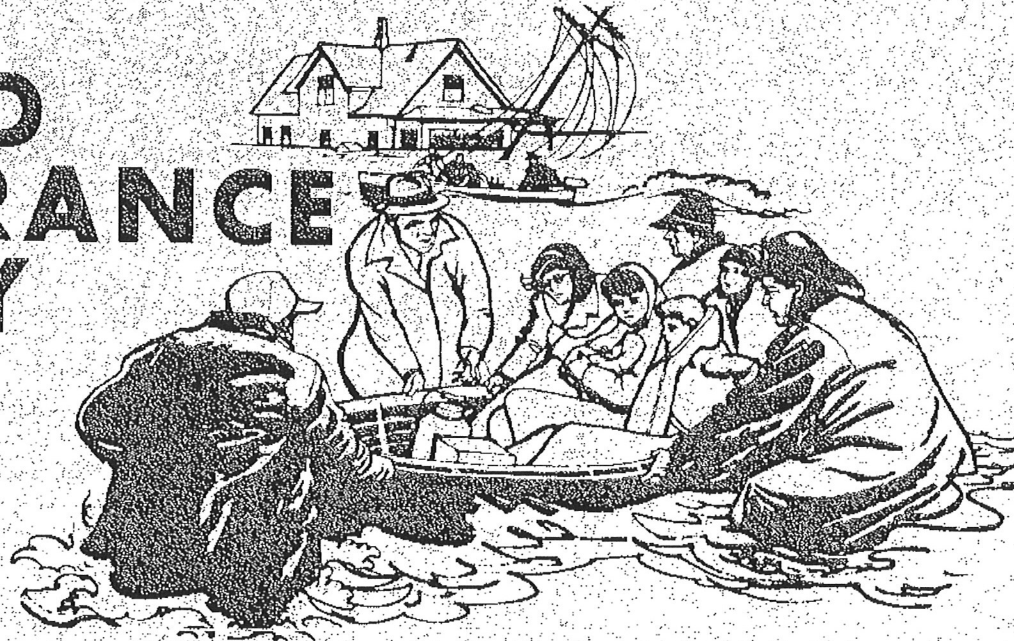
VISALIA (049367)
Extremes
Highest Daily Precipitation (inches)
Days: 1/1 - 12/31
Length of period: 1 day
Years: 1895-2007

Rank	Value	Ending Date
1	3.70	10/29/1974
2	3.22	1/11/1940
3	3.00	1/2/2006
4	2.45	3/13/1905
5	2.41	12/29/2001
6	2.22	4/5/2006
7	2.19	2/10/1978
8	2.16	1/20/1969
9	2.15	2/11/2001
10	2.08	2/25/1969

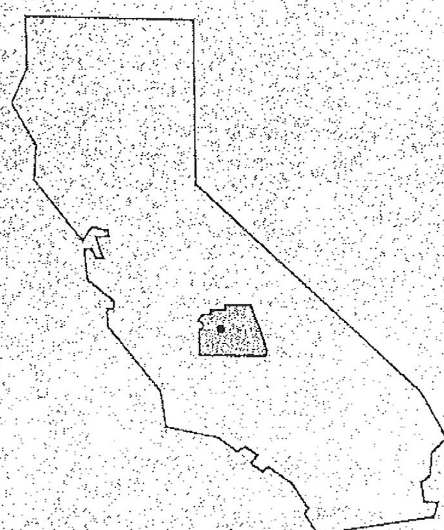
Official data and data for additional locations and years are available from the Regional Climate Centers **and the** National Climatic Data Center.

APPENDIX B
FEMA FLOOD INSURANCE STUDY

FLOOD INSURANCE STUDY



CITY OF FARMERSVILLE, CALIFORNIA
TULARE COUNTY



JUNE 15, 1983

Federal Emergency Management Agency

COMMUNITY NUMBER - 060405

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FLOOD INSURANCE STUDY

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Farmersville, Tulare County, California, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Farmersville to the regular program of flood insurance by the Federal Emergency Management Agency. Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3. In such cases, however, it shall be understood that the State (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, as amended.

The hydrologic and hydraulic analyses for this study were performed by James M. Montgomery, Consulting Engineers, Inc., for the Federal Emergency Management Agency, under Contract No. H-4727. This work, which was completed in March 1982, covered all significant flooding sources affecting the City of Farmersville.

1.3 Coordination

Areas requiring detailed study were identified at a meeting held in May 1978, attended by representatives of the Federal Emergency Management Agency, the study contractor, and the City of Farmersville. Results of the hydrologic analyses for Farmersville were coordinated with the U.S. Army Corps of Engineers, the U.S. Geological Survey, the U.S. Soil Conservation Service, the California Department of Water Resources, and the Tulare County Flood Control District.

Preliminary results of the study were presented to the community at an intermediate/final coordination meeting held on November

18, 1981, and attended by representatives of the City of Farmersville, the study contractor, and the Federal Emergency Management Agency. The study was acceptable to the community.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Farmersville, Tulare County, California. The area of study is shown on the Vicinity Map (Figure 1).

The limits of study in Farmersville were determined by the Federal Emergency Management Agency with community and study contractor consultation at the meeting in May 1978. Floods caused by overflow of Deep Creek within the corporate limits of the city were originally intended to be studied by detailed methods. However, preliminary hydraulic calculations indicated that 100-year flooding in Farmersville would not be readily associated with the Deep Creek channel, and would be at an average depth of less than 3 feet. Therefore, Deep Creek overflows were studied by the methods prescribed for conditions of shallow flooding, and the Deep Creek channel was studied by approximate methods. Extension Ditch was studied by approximate methods.

Those areas studied were chosen with consideration given to all proposed construction and forecasted development through 1987.

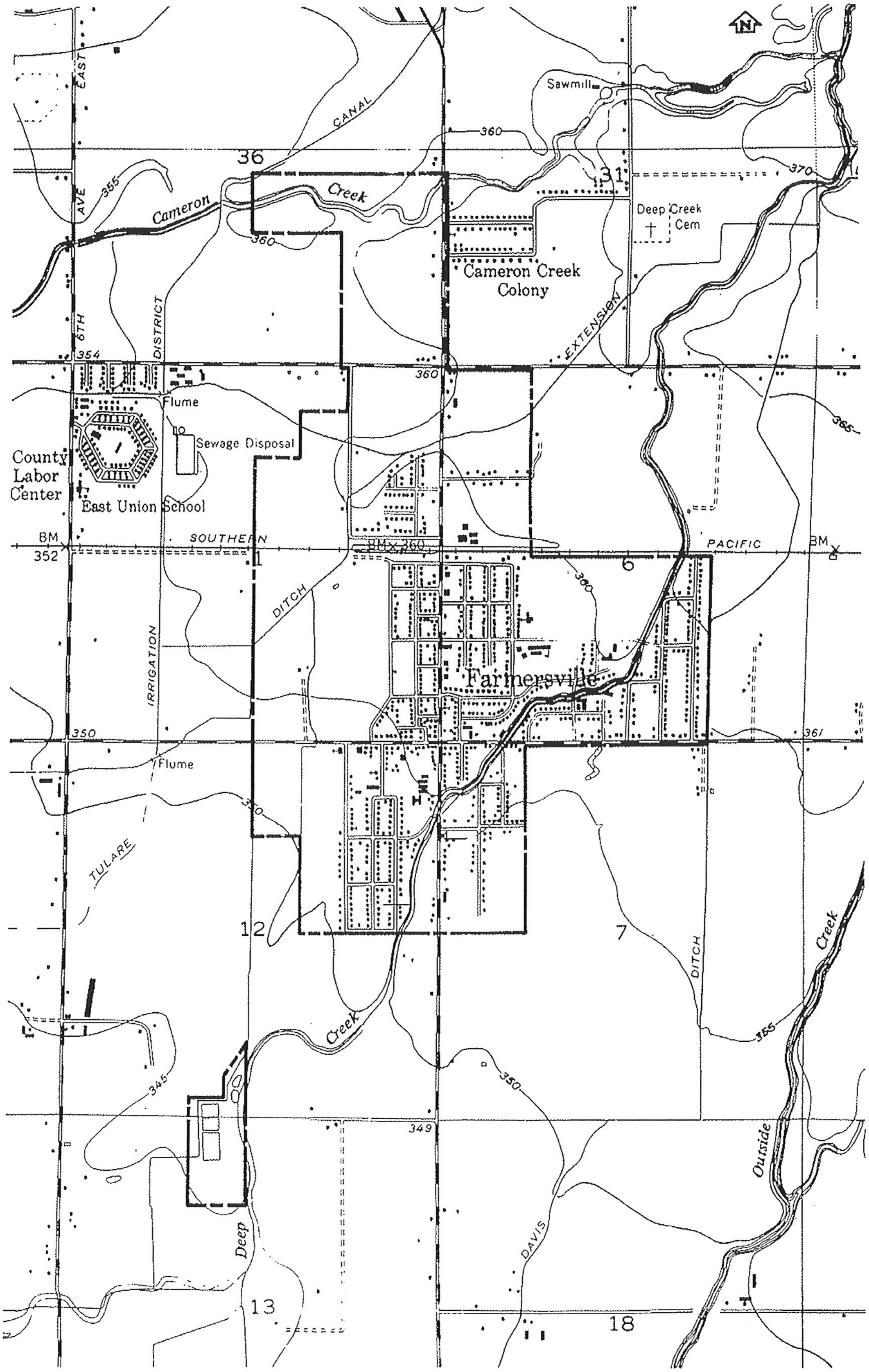
Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to and agreed upon by the Federal Emergency Management Agency and the City of Farmersville.

2.2 Community Description

The City of Farmersville is located in the San Joaquin Valley in central California, in the central portion of Tulare County. Farmersville is situated approximately 46 miles southeast of Fresno and 5 miles east of Visalia and is surrounded by unincorporated areas of Tulare County. The total land area incorporated by the city is approximately 1.2 square miles.

According to U.S. Census Bureau figures, the population increased from 3456 in 1970 to an estimated 3780 in 1975 (Reference 1). The population in 1980 was 5544, an increase in population of 60 percent since 1970 (Reference 2).

Development consists primarily of residences and commercial establishments. Approximately 93 percent of the residential housing units are single family dwellings. A large portion of the industry



APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF FARMERSVILLE, CA
(TULARE CO.)

FIGURE 1

is related to agriculture, the dominant business in the San Joaquin Valley. The main transportation artery serving the city is State Highway 198, which passes approximately one mile north of the corporate limits.

The primary watercourse contributing to flooding in Farmersville is Deep Creek, a distributary of Kaweah River. Deep Creek passes through the center of the city, and two other Kaweah River distributaries, Cameron Creek and Outside Creek, pass within one mile to the north and east, respectively, of Farmersville. Several irrigation canals are located in the vicinity of Farmersville including Extension Ditch, which receives its water from Consolidated Peoples Ditch and Deep Creek.

The climate is semi-arid and may be classified as "interior Mediterranean". Summers are hot and dry with low humidity, while winters are very mild with infrequent snowfall. Temperatures vary from average summer highs of approximately 100°F to average winter lows near freezing. The average annual precipitation at Farmersville is approximately 10.5 inches. However, floodwaters affecting Farmersville may originate near the headwaters of Kaweah River, where the average annual precipitation exceeds 45 inches. Eighty-five percent of the annual precipitation occurs between November and April (References 3 and 4).

The predominant soil type underlying Farmersville and the Deep Creek flood plain is described generally as a very deep fine sandy loam, nearly level to gently sloping, and moderately well to excessively drained. Vegetation is largely determined by current agricultural uses (Reference 5).

2.3 Principal Flood Problems

The past history of flooding in the City of Farmersville suggests that the flood season extends from November through June, with general rain floods occurring between November and April and snowmelt floods occurring from April to June. The majority of large floods have occurred during December, January, and February, and have been the result of heavy rains combined with snowmelt from the foothills and the Sierra Nevada Mountains.

There have been several major floods in recent history in the vicinity of Farmersville. These occurred in November 1950, December 1955, December 1966, and January 1969. In the past, the major flooding in Farmersville has been caused by breakouts of Deep Creek.

2.4 Flood Protection Measures

The primary flood protection facility affecting flooding in the Kaweah River distributary system is Terminus Dam, which has been operated for flood control by the U.S. Army Corps of Engineers since 1962. Lake Kaweah has a gross capacity of approximately 150,000 acre-feet (Reference 5). This dam has reduced potential flood hazards on Kaweah River and its distributaries, including Deep Creek. For example, the peak inflow to Lake Kaweah during the 1969 flood was 35,600 cubic feet per second (cfs), whereas the maximum release was 4,342 cfs. It is estimated that the project provides protection against a flood which would occur approximately once in 50 years.

No flood plain ordinances or flood protection measures are in effect in Farmersville.

3.0 ENGINEERING METHODS

In this engineering study, the nature of flooding in Farmersville has been identified as "shallow flooding". This is characterized by sheet flow or ponding with depths less than 3 feet. For the shallow flooding sources studied, standard hydrologic and hydraulic methods were used to determine the flood hazard data required for this study. A flood event of a magnitude which is expected to be equalled or exceeded once on the average during any 100-year period (recurrence interval) has been selected as having special significance for flood plain management and for flood insurance premium rates. Statistically, this event, commonly termed the 100-year flood, has a 1.0 percent chance of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, "rare" floods could occur at short intervals or even within the same year. The risk of experiencing a "rare" flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual occurrence) in any 50-year period is approximately 40 percent (4 in 10), and for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

Peak discharges for Deep Creek were determined as part of an overall hydrologic analysis of the Kaweah River distributary system. This analysis involved detailed hydrograph calculations, modified Puls routing, and divided flow analysis. A starting 100-year flood hydrograph was obtained for McKays Point, the upstream end of the distributary system, from an unpublished U.S. Army Corps of Engineers study for Kaweah River. This hydrograph was then adjusted to match the hydrograph peak discharge to the value presented on the graph "Rain-Flood Frequency Curves", October 1971, in the November 1971 revision of the reservoir regulation manual for Terminus Dam prepared by the U.S. Army Corps of Engineers (Reference 6). The resulting hydrograph was then routed downstream to Deep Creek using the modified Puls method. Major flow divisions between McKays Point and Deep Creek were determined by hydraulically modeling the major stream courses and flood plains utilizing the HEC-2 computer program. Minor diversions were accounted for using published flow capacities (Reference 6). Major tributary inflows were assumed to be constant at the mean annual peak flow.

Based on this analysis, the 100-year peak discharge for the Deep Creek channel downstream of Avenue 288 is estimated to be 2850 cfs. Downstream channel overflows reduce the channel discharge to 1550 cfs at the Southern Pacific Railroad; the remaining 1300 cfs is assumed to flow in the west overbank toward Farmersville. Additional overflows are assumed to occur between East Ash Street and Farmersville Boulevard, such that the 100-year discharge remaining in the channel at Farmersville Boulevard is 410 cfs.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flooding sources.

Elevations and depths of shallow flooding throughout Farmersville were computed using HEC-2 backwater analyses (Reference 7) and normal depth calculations. The cross sections and spot elevations needed in this analysis were obtained by photogrammetric techniques from aerial photographs taken in February 1979 at a scale of approximately 1 inch equals 925 feet (Reference 8) and from the most current U.S. Geological Survey topographic mapping for the study areas (Reference 9).

Channel roughness factors (Mannings "n" value) used in the hydraulic computations were chosen by engineering judgment and based on field observations of the study area. Roughness values ranged from 0.045 for agricultural areas to 0.100 for developed areas to account for obstructions and buildings.

The Federal Emergency Management Agency does not require the preparation of flood profiles in areas studied by approximate or shallow flooding methods; therefore, no flood profiles are presented in this report.

Shallow flooding is often characterized by highly unpredictable flow directions caused by low relief or shifting channels and high debris loads. Where such conditions exist, the entire area susceptible to this unpredictable flow has been delineated as a zone of equal risk. Small scale topographic variations have been averaged across inundated areas in determining flood elevations.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in the study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Emergency Management Agency as the base flood for purposes of flood plain management measures. The boundaries of the 100-year flood have been delineated using the flood depths determined at cross sections and spot elevations; between points of known elevation, the boundaries were interpolated using rectified photo topographic maps at a scale of 1:4,800 (Reference 10).

Flood boundaries are indicated on the Flood Insurance Rate Map (Exhibit 1). On this map, the 100-year flood boundary corresponds to the boundary of the areas of special flood hazards (Zone AH). Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights.

The Federal Emergency Management Agency does not require delineation of a floodway in areas studied by approximate or shallow flooding methods. Therefore, no floodway has been computed for the City of Farmersville.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the Federal Emergency Management Agency has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

Because flooding in Farmersville is shallow, the area does not lend itself to standard reach determinations as defined by the Federal Emergency Management Agency. Consequently, none were developed in these areas, and flood insurance zones were assigned directly based on the type of flooding conditions present in the community.

5.2 Flood Hazard Factors

The FHF is the Federal Emergency Management Agency device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

No Flood Hazard Factors were computed for the shallow flooding zones in Farmersville because they were not required under Federal Emergency Management Agency guidelines.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of Farmersville was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zone AH:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no FHFs are determined.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

The flood insurance zones and base flood elevations for each flooding source studied in detail in the community are summarized in Table 1.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Farmersville is, for insurance purposes, the principal result of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Deep Creek Shallow Flooding	0001	N/A	N/A	N/A	N/A	AH	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF FARMERSVILLE, CA
(TULARE CO.)

FLOOD INSURANCE ZONE DATA

DEEP CREEK

TABLE 1

accordance with the latest flood insurance map preparation guidelines published by the Federal Emergency Management Agency.

6.0 OTHER STUDIES

Flood Hazard Boundary Maps for the City of Farmersville and unincorporated areas of Tulare County have been published (References 11 and 12). These maps show boundaries of a Special Flood Hazard Area but do not show depths. This Flood Insurance Study indicates slightly more area flooded than shown on the Flood Hazard Boundary Maps. The difference is attributed to the availability of more complete and detailed topographic information and updated hydrologic data. This study supersedes the Flood Hazard Boundary Maps.

A Flood Plain Information report (Reference 4) was published by the U.S. Army Corps of Engineers in May 1972. In this report, flood boundaries for intermediate Regional Flood and Standard Project Flood conditions were shown. The Intermediate Regional Flood is a flood having an average frequency of occurrence on the order of once in 100 years, although the flood may occur in any year. This Flood Insurance Study indicates slightly less area flooded than shown for the Intermediate Regional Flood in the Flood Plain Information report. The difference is attributed to the availability of more complete and detailed topographic information and updated hydrologic data.

A Flood Insurance Study is being prepared for the unincorporated areas of Tulare County, California (Reference 13). Flood data computed and shown for unincorporated areas adjacent to the Farmersville corporate limits are consistent with the data given in this report.

This study is authoritative for the purposes of the National Flood Insurance Program; data presented herein either supersede or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, Building 105, Presidio of San Francisco, San Francisco, California 94129.

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